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disjunctive, general hypothetical and general disjunctive. After illustrating what he means by these terms, he shows how they are combined in the syllogism, which he defines as 'an interrelation of two judgments summed up in a third judgment.' His mode of symbolizing the relations of the propositions in the syllogism is in some respects new, and will be of interest to the formal logician.

The twelfth and last paper, by Dr. Overstreet, on *The Basal Principle of Truth-evaluation,* is an attempt to give positive character to the test by inconceivability of the opposite. The first part of the paper is devoted to a restatement of the dialectic of universal scepticism. His own positive conclusion is 'that the truth of any content whatever lies in the ability of that content to maintain itself completely.' 'Truth is an absolute uniformity or self-maintenance of meaning.'

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*The Principles of Mathematical Physics.* HENRI POINCARÉ. *The Monist,* January, 1905, Vol. XV., No. 1, pp. 1–25.

This article is an address delivered before the St. Louis Congress, translated by Professor Halsted. To review it here, when recourse to either the original or the translation can be had so easily, would not be worth while, did it not contain matter of philosophical interest not made explicit by the author, and yet very *à propos* to the recent frequent discussions of pragmatism. The author's general position is well known to many; yet it may be well to restate this.[1] For him the axioms of geometry are neither synthetic judgments *a priori* nor experimental facts, but rather conventions, definitions. Our choice among them remains free, and is limited only by the necessity of avoiding all contradiction.

The foundation of mechanics is closely similar, yet with a difference. Although the fundamental principles of geometry are conventions set up in studying space, because of experiments in physiology and mechanics, they do not refer to the objects experimented with. The principles of mechanics *do,* however, relate to these objects, and that science must remain experimental. The author views such hypotheses in physical science as that matter is continuous or that it is atomic as indifferent. This ought to be most critically suggestive to him who claims that, corresponding to, *e. g.,* atomic (molecular) formulæ, real atoms must exist. The real aim of the scientist is not to find out whether, *e. g.,* the ether is or is not formed of atoms, but to foresee optical phenomena. The differential equations by which he does this express relations; the former are true if the latter preserve their reality. We may *image* the relation by substituting for the equation some appellation like movement or current, but 'the real objects will remain eternally hidden from us.' If, then, between the members of different sets of images the same relations respectively exist as between the objects, one is free to choose his imagery. The differential equation is then an abstraction presenting the common features of, *e. g.,* periodic phenomena, some of which may be those of motion, but all are not necessarily so. It means simply that between all periodic phenomena there exists a close and abstract relationship which corresponds to a profound reality, and is the consequence of more general principles of energy, of least action, etc.

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[1] Cf. 'La Science et l'Hypothèse,' Paris, 1903.

We find this general position of Poincaré to be very much the same as that taken by Duhem in a recent series of articles.[2] For the latter 'a physical theory is a system of mathematical propositions, deduced from a small number of principles, which aim to *represent* as simply, as completely and as exactly as possible, an *ensemble* of experimental laws.'

In both positions we discover three implications which are of philosophic interest. The first is that, as we *use* or think these mathematical propositions, it is not only unnecessary, but indeed *impossible,* to present images which shall constitute or be adequate to their meaning. In this there is indicated also the psychological nature of scientific thinking in some fields. It is essentially *symbolic* and *efficient.* Secondly, although in response to the desire to *conceive* how something is possible, some image or series of images may be formed and some appellation, *e. g.,* movement, given, not only are these images inadequate, but it is quite possible, if images be insisted on, to get different sets of them. Accordingly different systems within almost any of the different fields of knowledge may arise, each with as good and no better claims than the others. Thirdly, and in connection with these two, a mathematical proposition (differential equation) may be *effectively* or efficiently used to control and foresee phenomena without any images at all being presented, and, accordingly, without any question as to that *truth* which has been held to consist of a correspondence between them as ideas and real things. Symbolism and pragmatism, then, go here hand in hand. In seeking knowledge in physics and chemistry one may say, indeed, that we are after *not truth, but efficiency, efficient symbols* and their rules-of-the-game-like manipulation, as an instrument of control and foresight. Paradoxically, their use makes a man *able to do;* his general position, his thinking all reality in the likeness of some image, can determine only what he does.

In his present paper Poincaré 'diagnosticates' the case of physics in the crisis through which it is now passing—crisis because of 'Zeeman effects' and radium and 'Brownian movements,' etc., and in so doing he recognizes the above principles.

Mathematical physics, born of celestial mechanics, represented all nature as 'springing' from masses which attracted and repelled each other according to some exponent, not always —2, but perhaps —5 or —6 (Briot's atoms of ether). It rendered the further service of 'making precise the notion of the physical law as not something static and immutable, but as a differential equation.' The reviewer finds in this origin one reason for the persistent attempts made to image all phenomena in terms of the changes in the configuration of minute hard masses, *i. e.,* for one kind of atomism, a mode of *conceiving* which emphasizes particularly the keeping of the law of identity intact.

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[2] *La théorie physique, son objet, sa structure,* P. Duhem. *Revue de Philosophie,* April, 1904–January, 1905.

But for our author this mode of conceiving is not necessary. He finds that the first crisis arrived when this conception of 'central forces' no longer appeared sufficient. 'One gave up trying to penetrate into the *detail* of the structure of the universe, and was content to take as guides certain *general principles* whose object is to spare us this minute study.' Thus, for example, in a machine in which the initial and final wheelwork is alone visible, and the nature of the internal mechanism is not known, the principle of conservation suffices to determine for us what ratio the couples applied to each wheel must have in order to effect compensation.

Our author mentions six general principles whose application as 'rules of the game' enables us to draw conclusions, whatever may be the invisible mechanism in nature. These have resulted from experiments with objects and refer to these, yet are nevertheless conventions and may not always be found efficient.

They are: (1) the conservation of energy, (2) its degradation, (3) the equality of action and reaction, (4) relativity, (5) the conservation of mass and (6) least action.

To illustrate their application, he says that although 'we know nothing as to what is the ether, how its molecules (?) are disposed, whether they attract or repel each other, we do know that its transmission of optical and electrical perturbations is made conformably with these general principles of mechanics, and that suffices for the establishment of the equations of the electromagnetic field.'

'The hypothesis of central forces contained all the principles,' but now this conception has become a useless support, or rather embarrassment, since it makes the principles partake of its hypothetical character. Enlarged, found in different vestments, consolidated as these principles have been, are they now to crumble away in the presence of radium and Brownian movements, etc.? A second crisis!

Take the principle of Carnot, the only one not an immediate consequence of the hypothesis of central forces; for if to these all physical phenomena were due, then all these should be reversible. But this was not so in nature. Events could not be turned backward without the hands of the Maxwellian demon. At least so it was thought until recently the microscopist saw in the movements of little particles in suspension motion transformed into heat and conversely, and the Carnot principle was imperiled.

Even the principle of relativity, according to which the laws of physical phenomena should be the same whether for an observer fixed or for one carried along in a uniform movement of translation, has been attacked: Take two electrically charged bodies, seemingly at rest; the earth nevertheless carries them; but a charge in motion is a current; we have, therefore, really two currents which attract each other. Measure this attraction, and have we not measured the velocity of the earth absolutely and not relatively?

Again it has been attacked in the very ingenious attempts made to measure the velocity of the earth in relation to the ether, but the results have been negative. To explain this obstinacy the mathematicians have had to *accumulate* hypotheses, such as that bodies in motion undergo a uniform contraction in the sense of the motion and that in forces those components which are perpendicular to the translation of the earth are reduced. 'The very energy of the defense proves how serious has been the attack' on the principle of relativity.

So, also, has the Newtonian principle of the equality of action and reaction been questioned. It has been held that one electron makes another at a distance vibrate through the mediation of the 'intervening ether.' Evidently the compensation between the action and reaction could not be simultaneous; the perturbation has a finite velocity. If the action and reaction be held to take place between the ether adjacent to the electron and this latter, this is contrary to the principle of Newton, since the projectile here has no mass; it is not matter, but energy. Analogously and experimentally it is possible to get what is termed the 'Maxwell-Bartholdi' pressure of light.

One way out of the difficulty, seemingly, is to suppose the ether attached to some *material* substratum; but this has been experimentally disproved by Fizeau, and Michaelson and Morley. Another is that 'the movements of matter are exactly compensated by those of the ether; but the principle so extended would explain everything since, whatever might be the visible movements, we could always imagine hypothetical movements which compensated them.' But able to explain everything, it permits us to foresee nothing, it becomes inefficient and useless.

In this we again discover Poincaré's recognition of a view-point we have previously emphasized, viz., that a general or universal principle may influence what a man does or wishes to do, but can not make him able to do. The conviction, *e. g.*, that *everything* is energy and that this is conserved, does not always enable one the better to foresee and control phenomena. This can be done at present only by the mathematical symbolization of *experimentally* measurable quantities in the form of an equation. Put in another way, one may say that if a term be raised to a genus it can no longer be used as a species by which to differentiate, yet differentia must be discovered in order to predict and control. We will leave it to the reader to make the application to panpsychism, etc., and return to our author's presentation of the attack on Lavoisier's principle of the conservation of mass.

'The calculations of Abraham and the experiments of Kaufmann have shown that the mechanical mass is null, and that the mass of the electrons, at least of the negative ones, is of exclusively electrodynamic origin; there is, therefore, no mass other than this latter, and this augments with the velocity and even depends on the direction.' 'So-called mechanical masses will vary in accordance with the same laws as the electrodynamic masses. And if no longer a constant mass then there is no longer a center of gravity.' 'And if the coefficient of inertia is not constant can the attracting mass be?' That is the question. We here see the difficulty which has been felt from, say, the time of Maxwell in defining mass crystallized by the shock of recent experimental work.

We now come to the principle of the conservation of energy. This is 'strained' by all the recent work on radioactive bodies. They 'create' incessantly (?) a notable amount of heat. Sir Wm. Ramsay, to be sure, says this store of energy is, however, quite exhaustible, say, in 1,250 years.

But let it be conjectured, by way of explanation, that, *e. g.*, radium is only an intermediary taking up energy and giving it out in divers forms! Then our general principle is saved; but by what an advantageous, convenient, unverifiable and irrefutable explanation! All the objections of future experimenters are answered beforehand; they can not assail the principle. It is intact; but of what *use?* Made general, how inefficient!

'In the presence of this general ruin of the principles, what attitude will mathematical physics take?' First, it is proper to ask if all of this is really true, for all these objections are encountered only among infinitesimals. However, only *experiment* can settle the question, and in the meantime we are to continue our work as if the principles were still uncontested, or, in the face of our doubts, make an effort to save them. We must 'heap up hypotheses,' leaving it to the experimentalists to seek the *crucial* experiment with which to decide between them.

But suppose all such efforts fail, and we can not reconcile the principles with the results of experiment. Shall we try to mend them by a *coup de pouce,* like that one used in accounting for the energy of radium? That is always possible, but with it the principle would cease to be fecund.

Consequently 'it would be necessary to rebuild anew,' to have a third period bearing traces of the second as this did of the first. And in this perhaps it is the kinetic theory of gases which is about to serve as a model for the others. The laws of chance will then make a very great number of elementary facts cooperate for a common end. 'Physical law will then no longer be solely a differential equation, but will take the character of a *statistical* law.' We should, perhaps, likewise have a whole new mechanics where inertia increases with the velocity! Ordinary mechanics would remain a first approximation, true for velocities not too great, and we would still act as if we believed in the principles, as if they were true within these limits. They are too useful to deprive ourselves of them entirely, but they would not be efficient for data though extended universally.

In conclusion, we may repeat the statement of the principles of philosophical interest which the author seems to make use of. These are: Mechanical principles are *conventions* set up because of and referring to objects experimented with. These, as the results of certain other experiments show, are, if not false, at least useless if extended universally. A physical law or theory consists of mathematical equations containing symbols for real relations, and by the manipulation of these equations enables us to predict and to control (scientific symbolism and pragmatism) in an experiment without presenting images (atoms, etc.) for the meaning of these symbols, and as to the structure of objects; such equations apply to changes of state, of quality, etc., as well as to those of position; if images be insisted on, different systems are possible. Physical science is indifferent to truth if this be only the correspondence between images and reality, but rather is concerned with the efficient instruments of manipulation and experimentation, *i. e.,* with symbols, equations and with facts. Only in this way is the use of apparatus made possible. These—symbols, conventional principles, equations, their manipulation—and experiments with these in mind are the aspects and means of knowledge in those fields in which we are most *able to do.* This is pragmatism and not absolutism.

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## JOURNALS AND NEW BOOKS

JOURNAL OF COMPARATIVE NEUROLOGY AND PSYCHOLOGY. January, 1905. *On the Areas of the Axis Cylinder and Medullary Sheath as Seen in Sections of the Spinal Nerves of Vertebrates* (pp. 1–16): H. H. DONALDSON and G. W. HOKE. – The areas, in cross section, of the axis cylinder and of the medullary sheath are very nearly equal to each other; and this holds true, with deviations of less than two per cent., of all classes of vertebrates above the Cyclostomes. *On the Number and Relations of the Ganglion Cells and Medullated Nerve Fibers in the Spinal Nerves of Frogs of Different Ages* (pp. 17–56): IRVING HARDESTY. – There are about three times as many cells in the frog's spinal ganglia as fibers in the dorsal roots; there are always more fibers in the combined nerve distal to the ganglion than in the two roots together. Some of this 'distal excess' is accounted for by the bifurcation of fibers, both sensory and motor, which occurs to a limited extent just distal of the ganglion; another known factor, and probably the most important, is the incoming of sympathetic fibers which pass into the ganglion and end there; it is also possible, though not proved, that some of the cells of the ganglia, while sending no fiber inward to the cord, send one outward. The 'distal excess' increases with the age of the frog. *Editorial. Psychology and Neurology* (pp. 57–61): H. HEATH BAWDEN. – There is need for the two sciences that deal with the nervous system to cooperate in investigation and discussion, but this is made difficult by the diverse history and metaphysics of their concepts. When once the energic conception, applied to both matter and mind, has thoroughly penetrated biology and psychology, it will go far toward removing the difficulty. *The International Commission on Brain Research* (pp. 62–65): G. ELLIOT SMITH. – History of the origin of the Commission, and account of its first meeting in London in May, 1904. *Literary Notices.*

ZEITSCHRIFT FÜR PSYCHOLOGIE UND PHYSIOLOGIE DER SINNESORGANE. January, 1905, Band 37, Heft 1 u. 2. *Quantitative Untersuchungen über die Bleichung des Sehpurpus in monochromatischen Licht* (pp. 1–55): WILHELM TRENDELENBURG. – The curve of the bleaching effect of spectral colors is well-nigh identical with that of the threshold values of these colors in faint light vision and this again identical with the curve of the energy absorbed. Results are in accord with theory that visual purple reenforces faint light vision. *Experi-*